Claims

1) Method for the production of a sensor for evaluation of the concentration of analyte elements (a_i) of an analyte (A) [that is to say soluble chemical entities or live or dead micro-organisms, or parts of micro-organisms] which are present in a fluid sample (F) included initially in a sample volume (Vec), this method being of the type according to which the following steps are carried out:

a) a fraction of the fluid sample (F) is channelled in the interior of a test volume (Vep),

i) circumscribed by an enclosing reaction surface (Sev) [topologically, the smallest continuous surface surrounding the said test volume (Vep)],

ii) provided internally within a reaction chamber (Cre),

iii) the said enclosing reaction surface (Sev) being constituted by:

- a permeable upstream front face (sfam),
- permeable downstream front face (sfav) situated opposite the permeable upstream face (sfam),
- and a substantially cylindrical impermeable lateral face (slat) connected by its two ends to the peripheries of the said two upstream (sfam) and downstream (sfav) faces;

b) the fluid sample (F) is placed in contact, within the test volume (Vep), with an active component (chemical and/or biological) known as a receptor (R):

i) of which the receptor elements (r_j) have an affinity with the analyte elements (a_i) in order to detect them,

ii) and moreover having the property [alone or in combination with another active component known as a indicator (U) likewise introduced into the interior of the test volume (Vep)] of modifying by an elementary signal (dE), a measurable extensive state variable (physical and/or chemical) (E), at each occurrence [or according to a certain law of probability], during an event of recognition of an analyte element (a_i) by a receptor element (r_j),

c) by means of a measurement transducer system (T) the variations in the said extensive state variable (E) are measured in such a way as to quantify the presence of the analyte elements (a_i) in the fluid sample (F) in the form of an exploitable analytical signal (Se) ;

This method of evaluation of concentration being characterised in that in combination:

d) on the one hand, the fraction of the fluid sample (F) is multi-channelled in parallel through a reaction chamber (Cre) in the form of

a monolithic multi-microtubular array, that is to say constituted by the joining of a plurality of cylindrical micro-tubular channels disposed substantially parallel and multi-tangent (c_1, c_2, ..., c_k, ..., c_n),

i) cylindrical [that is to say each delimiting an elementary internal surface (sep_k) generated topologically by the displacement along an elementary central line of a continuous virtual skeleton (l_k) of a curve of continuous and closed shape (f_k) placed substantially perpendicular],

ii) microtubular [that is to say of which the elementary internal section (s_k) perpendicular to their elementary central line (l_k) has at least one selective transverse dimension (dx) several orders of magnitude smaller than its length (l) (typically of the order of 1000 times smaller)],

iii) with lengths (l) [that is to say the length of elementary central lines (l_k)] which are substantially equal,

iv) disposed substantially parallel [that is to say of which the elementary central lines (l_k) are disposed substantially parallel],

v) and multi-tangent [that is to say of which each micro-tube (c_k) is in longitudinal contact over substantially all its length with at least one other adjacent micro-tube ($c_{k'}$)],

vi) thus delimiting a dense plurality of adjacent separate convex elementary volumes (vec_1, vec_2, ..., vec_n) which are open at their two ends and of which the joining constitutes the non-convex global test volume (Vep), this latter being circumscribed by the enclosing reaction surface (Sev) of which the permeable upstream (sfam) and downstream (sfav) front faces are situated at right angles to the inlet (se_k) and outlet (ss_k) sections of the microtubular channels (c_1, c_2, ..., c_k, ..., c_n);

e) on the other hand, the lateral integral measurement transducer system (T) for the extensive state variable (E) is positioned laterally to the reaction chamber (Cre), that is to say

i) entirely outside the enclosing surface (Sev) of the reaction chamber (Cre),

ii) and strictly facing the impermeable lateral face (slat),

f) finally, by means of the lateral integral measurement transducer system (T) an integral measurement $\Delta E = \Sigma_{k=1...n} \Sigma_{ij} (dE)_{ijk}$ is carried out, that is to say

i) a summation of the variations $(dE)_{ijk}$ in the said extensive state variable (E),

ii) simultaneously for all the elementary volumes (vec_k) at once,

iii) and for all the elementary signals $(dE)_{ijk}$ in each elementary tube (c_k) at once,

iv) through the impermeable lateral face (slat),

in such a way as to quantify globally the presence of the analyte elements (a_i) in the fluid sample (F) in all the microtubular channels $(c_1, c_2, ..., c_k, ..., c_n)$ at once.

2) Method according to Claim 1 for the production of a sensor for evaluation of the concentration of analyte elements (a_i) of a biological analyte (A), constituted by live or dead micro-organisms (a_i) [such as microscopic fungi, bacteria, or parts of micro-organisms] of typical diameter (dt) [typically situated between 0.01 microns and 10 microns], this method being characterised in that furthermore:

a) the fraction of the fluid sample (F) charged with biological analyte elements (a_i) is multi-channelled in parallel through a reaction chamber (Cre) in the form of a monolithic multi-microtubular array constituted by the joining of a plurality of microtubular channels $(c_1, c_2, .., c_k, .., c_n)$, of which the said selective transverse dimension (dx) is chosen in correlation with the typical diameter (dt) of the biological analyte elements (a_i), [typically the elementary internal section (s_k) of the microtubular channels (c_k) is chosen in such a way that their said transverse dimensions (dx) are substantially equal to approximately 10 times the typical diameter (dt) of the biological analyte elements (a_i), that is to say in particular of the order of magnitude of 10 microns if the biological analyte elements (a_i) are bacteria].

3) Method according to Claim 1, for the production of a sensor for evaluation of the concentration of analyte elements (a_i) of an analyte (A), this method being characterised in that furthermore in combination:

a) on the one hand, the fraction of the fluid sample (F) charged with analyte elements (a_i) is multi-channelled in parallel through a reaction chamber (Cre) in the form of a bi-periodic monolithic multi-microtubular array (Cre) constituted by the joining of a plurality of n ($n \cong$ approximately 300 000) microtubular channels (c_k),

i) of quasi-revolutionary cross-section [that is to say a cross-section with a curve of continuous shape (f_k) such as a circle, ellipse, polygon, oval, ..., of which any pair of two perpendicular transverse dimensions (dx, dy) are of the same order of magnitude (d)]

ii) of internal transverse dimensions ($d = dx = dy \cong$ of the order of 10 microns) which are substantially identical,

iii) disposed parallel, adjacent and joined in a common axial direction (zz') of orientation of their elementary central lines (l_k),

iv) and organised according to a bidimensional periodic network (Rxy) perpendicular to the said common axial direction (zz') of orientation,

b) on the other hand, the said lateral integral measurement transducer system (T) for the extensive state variable (E) is positioned

i) substantially surrounding the exterior of the impermeable lateral face (slat),

ii) at a radial distance (Re) of the order of magnitude of Re $\cong$ (2,1 *$\sqrt{}$ (n /π) * d) from the axis constituted by the said common direction (zz') of orientation of the reaction chamber (Cre) (that is to say Re $\cong$ 7mm).

4) Method according to Claim 1, for the production of a sensor for evaluation of the concentration of analyte elements (a_i) of an analyte (A), this method being characterised in that furthermore in combination:

a) on the one hand, the fraction of the fluid sample (F) charged with analyte elements (a_i) is multi-channelled in parallel through a reaction chamber (Cre) in the form of a monoperiodic lamellar monolithic multi-microtubular array (Crel), constituted by the joining

i) of a plurality of n (n $\cong$ approximately 1 000) microtubular channels (c_k),

ii) with lamellar cross-sections (sel_k) [that is to say a cross-section with a curve of substantially rectangular shape (f_k), of which two perpendicular transverse dimensions (dx, dy) are different by at least one order of magnitude (dx << dy)], typically :

- a selective transverse dimension (dx) is of the order of 10 microns,
- a lateral transverse dimension (dy) is of the order of 10 millimetres,

iii) disposed parallel, adjacent and joined in a common planar direction (yOz) of orientation of their elementary central lines (l_k),

iv) according to a monodimensional periodic network (Rx) perpendicular to the said common planar direction (yOz) of orientation,

b) on the other hand, the said lateral integral measurement transducer system (T) for the extensive state variable (E) is positioned substantially surrounding the exterior of the impermeable lateral face (slat).

5) Method according to Claim 1, for the production of a sensor for evaluation of the concentration of analyte elements (a_i) of an analyte (A), this method being characterised in that furthermore in combination:

a) on the one hand, the fraction of the fluid sample (F) charged with analyte elements (a_i) is multi-channelled in parallel through a reaction chamber (Cre) constituted by the joining

i) of a plurality of n substantially identical microtubular channels (c_1, c_2, ..,c_k,.., c_n),

ii) parallel and adjacent, which have been disposed transversely and joined in the form of an array constituting a substantially cylindrical bidimensional periodic network (Rxy), such that the impermeable lateral face (slat) of the reaction chamber (Cre) has substantially the shape of a cylinder (Cyre) with a circular cross-section of diameter (De),

b) on the other hand, the said lateral integral measurement transducer system (T) for the extensive state variable (E) is positioned surrounding the exterior of the cylindrical impermeable lateral face (slat) in a substantially annular fashion in such a way as to optimise the ratio of efficiency of measurement (ref = n / Re) between :

i) the number (n) of microtubular channels,

ii) and the distance (Re) between the said lateral integral measurement transducer system (T) for the extensive state variable (E) and the axis (zz') of the reaction chamber (Cre).

6) Method according to Claim 5, for the production of a sensor for multi-location evaluation of the concentration of analyte elements (a_i) of an analyte (A), this method being characterised in that furthermore:

a) in a first sampling site (L1),

i) the fraction of the fluid sample (F) charged with analyte elements (a_i) is multi-channelled in parallel through a reaction chamber (Cre) in the form of a monolithic cylindrical multi-microtubular array, in the form of a mobile test cartridge (Car), constituted by

- the joining of a plurality of n substantially identical microtubular channels (c_k),
- of which the impermeable lateral face (slat) has substantially the shape of a cylinder (Cyre) of cartridge diameter (Dc),

b) in a second indication site (L2), (possibly merged with the first or the third)

i) inside the global test volume (Vep) of the reaction chamber (Cre) the fluid sample (F) is placed in contact with

- an active component (chemical and/or biological) known as a receptor (R) of which the receptor elements (r_j) have an affinity with the analyte elements (a_i) in order to detect them,
- and possibly with another active component known as a indicator (U), possibly merged with the receptor (R),

in such a way as to modify by an elementary signal (dE) a measurable extensive state variable (physical and/or chemical) (E), at each occurrence or according to a certain law of probability, of the recognition of an analyte element (a_i) by a receptor element (r_j) within the test volume (Vep),

c) in a third measurement site (L3), separate from the first,

i) the said lateral integral measurement transducer system (T) for the extensive state variable (E) is disposed around the external lateral surface (Secm) of the periphery of a measurement block (Cme) which is substantially cylindrical and of small thickness (epcm), providing a cylindrical internal measurement cavity (Eme) with a measurement block diameter (Dm) greater than but substantially equal to the said cartridge diameter (Dc),

ii) the mobile test cartridge (Car), including the reaction chamber (Cre) in the form of a multi-microtubular array, is introduced into the interior of the cylindrical internal measurement cavity (Eme) of the measurement block (Cme),

iii) finally, by means of the lateral integral measurement transducer system (T) an integral measurement of the variations of the said extensive state variable (E) is carried out simultaneously through

- the external lateral surface (Secm) of the measurement block (Cme),
- the lateral wall (Cpl) of the test cartridge (Car),
- and the impermeable lateral face (slat) of the reaction chamber (Cre).

7) Method according to Claim 6 for the production of a sensor for multi-location evaluation of the concentration of analyte elements (a_i) of an analyte (A), this method being characterised in that furthermore in the first sampling site (L1) and/or second indication site (L2),

a) the mobile test cartridge (Car) is immersed successively into the interior of a succession of wells (51, 52, 53, 54) containing different fluids (55) such as the fluid sample (F) and/or reagents which at least one is a receptor (R) of the analyte (A),

b) and after each introduction into a well (51, 52, 53, 54), a fraction of the fluid (55) within the well (51, 52, 53, 54) is drawn in and multi-channelled through the reaction chamber (Cre) in the form of a multi-microtubular array.

8) Method according to Claim 7 for the production of a sensor for multi-location evaluation of the concentration of analyte elements (a_i) of an analyte (A), this method being characterised in that furthermore in the first sampling site (L1) and/or second indication site (L2), and after each

intake of a fluid (55) inside a well (51, 52, 53, 54), through the reaction chamber (Cre) this fluid (55) from the different micro-tubular channels (c_k) is forced towards the same well (51, 52, 53, 54).

9) Method according to Claim 6 for the realisation of a sensor for multi-location evaluation of the concentration of analyte elements (a_i) of an analyte (A), this method being characterised in that furthermore:
   a) on the one hand, the impermeable lateral face (slat) of the reaction chamber (Cre) in the form of a monolithic multi-microtubular array is given
      i) the overall shape of a quasi-cylinder (Cyre) of cartridge diameter (Dc),
      ii) of slightly truncated conical shape, with an angle at the top (tc),
   b) on the other hand, the cylindrical internal measurement cavity (Eme) of the measurement block (Cme) is given a slightly truncated conical shape, with an angle at the top (tc)
   c) finally, the truncated conical multi-microtubular reaction chamber (Cre) is positioned inside the internal truncated conical measurement cavity (Eme) of the measurement block (Cme) in such a way as to ensure a close contact and to allow:
      i) a reduction of the distance between the lateral integral measurement transducer system (T) and the reaction chamber (Cre),
      ii) and a possible pressurisation in order to avoid the lateral leakages between the reaction chamber (Cre) and the measurement block (Cme).

10) Method according to Claim 6 for the realisation of a sensor for multi-location evaluation of the concentration of analyte elements (a_i) of an analyte (A), this method being characterised in that furthermore:
   a) on the one hand, the mobile cartridge (Car) including the cylindrical reaction chamber (Cre) is displaced between at least one indication site and a measurement site,
   b) on the other hand, the reaction chamber (Cre) is coated with an identifier (Id) prior to the displacement.

11) Method according to any one of the preceding Claims 1 to 10 for the production of a biosensor with sandwich analysis for evaluation of the concentration of analyte elements (a_i) of an analyte (A), this method being characterised in that furthermore:
   a) a plurality of receptor elements ($r1_m$) of a receptor (R1) (such as an antibody of the analyte (A)) which has an affinity with the analyte elements (a_i) in order to detect them is introduced into the interior of the plurality of microtubular channels (c_k) of the reaction chamber (Cre) and is attached to the internal surfaces thereof (sep_k),

b) the fraction of the fluid sample (F) is multi-channelled in parallel through the plurality of microtubular channels (c_k) of the reaction chamber (Cre) in such a way that the analyte elements (a_i) come into contact and bond to the receptor elements ($r1_m$) immobilised on the internal surfaces (sep_k),

c) there are multi-channelled in parallel through the plurality microtubular channels (c_k) of the reaction chamber (Cre), a plurality of receptor elements (r_j) of a receptor (R) (such as an antibody for the analyte (A)) which has an affinity with the analyte elements (a_i) in order to detect them and which also has the property [alone or in combination with another active component known as a indicator (U) likewise introduced into the interior of the test volume (Vep)] of modifying by an elementary signal (dE) a measurable extensive state variable (physical and/or chemical) (E), at each occurrence [or according to a certain law of probability], at the time of the chemical bonding between an analyte element (a_i) and a receptor element (r_j),

d) a lateral integral measurement transducer system (T) for the extensive state variable (E) is positioned

i) entirely outside the enclosing surface (Sev) the reaction chamber (Cre),

ii) and strictly facing the impermeable lateral face (slat),

e) finally, by means of the lateral integral measurement transducer system (T) an integral measurement $\Delta E = \Sigma_{k=1...n} \Sigma_{ij} (dE)_{ijk}$ is carried out (that is to say a summation) of the variations of the said extensive state variable (E), expressing the creation of the complexes (analyte element (a_i) = receptor element (r_j) and possibly developer (U)) simultaneously for all the elementary volumes (vec_k) at once, and for all the elementary signals $(dE)_{ijk}$ in each elementary tube (c_k) at once through the impermeable lateral face (slat).

12) Method according to any one of the preceding Claims 1 to 10 for the production of a biosensor with displacement analysis for evaluation of the concentration of analyte elements (a_i) of an analyte (A), this method being characterised in that furthermore:

a) a plurality of analogue elements (b_m) of a chemical analogue (B) of the analyte (A) are introduced into the interior of the plurality of microtubular channels (c_k) of the reaction chamber (Cre) and are attached to the internal surfaces thereof (sep_k),

b) in the interior of the plurality of microtubular channels (c_k) of the reaction chamber (Cre) there are multi-channelled in parallel a plurality of receptor elements (r_j) of a receptor (R) (such as an antibody Ab common to the analyte (A) and to its analogue (B)) which has an affinity with the analyte elements (a_i) and the analogue

elements (b_m) in order to detect them and which also has the property [alone or in combination with another active component known as a indicator (U) likewise introduced into the interior of the test volume (Vep)] of modifying a measurable extensive state variable (physical and/or chemical) (E) by an elementary signal (dE) at each occurrence or according to a certain law of probability at the time of the chemical bonding between an analyte element (a_i) or an analogue element (b_m) and a receptor element (r_j), such that the receptor elements (r_j) bond to the said analogue elements (b_m) immobilised on the internal surfaces (sep_k) of the reaction chamber (Cre),

c) the fraction of the fluid sample (F) is multi-channelled in parallel through the plurality of microtubular channels (c_k) of the reaction chamber (Cre) in such a way that the analyte elements (a_i) competitively bond with the analogue elements (b_m) and displace some of the receptor elements (r_j) immobilised on the internal surfaces (sep_k) of the reaction chamber (Cre),

d) a lateral integral measurement transducer system (T) for the extensive state variable (E) is positioned

i) entirely outside the enclosing surface (Sev) of the reaction chamber (Cre),

ii) and strictly facing the impermeable lateral face (slat),

e) finally, by means of the lateral integral measurement transducer system (T) an integral measurement $\Delta E = \Sigma_{k=1\ldots n} \Sigma_{ijm} (dE)_{ijkm}$ is carried out (that is to say a summation) of the variations of the said extensive state variable (E), each elementary signal $(dE)_{ijkm}$ expressing the disappearance of the complexes (analogue element (b_m) = receptor element (r_j)) simultaneously for all the elementary volumes (ve_{ck}) at once, and for all the elementary signals $(dE)_{ijkm}$ in each elementary tube (c_k) at once through the impermeable lateral face (slat).

13) Method according to any one of the preceding Claims 1 to 10 for the production of a biosensor with displacement analysis for evaluation of the concentration of analyte elements (a_i) of an analyte (A), this method being characterised in that furthermore:

a) a plurality of receptor elements (r_j) of a receptor (R) (such as an antibody Ab of the analyte A) which are immobilised on the internal surfaces (sep_k) of the reaction chamber (Cre) are introduced into the interior of the plurality of microtubular channels (c_k) of the reaction chamber (Cre),

b) there are likewise introduced into the interior of the plurality of microtubular channels (c_k) a plurality

i) of analogue elements (b_m) of a chemical analogue (B) of the analyte (A),

ii) each conjugated with a indicator element (u_m) of another active component known as a indicator (U) and capable of modifying a measurable extensive state variable (physical and/or chemical) (E) by an elementary signal (dE),

iii) such that the analogue elements (b_m) and their conjugated indicator elements (u_m) are immobilised on the internal surfaces (sep_k) of the reaction chamber (Cre) in contact with the receptor elements (r_j),

c) the fraction of the fluid sample (F) is multi-channelled in parallel through the plurality of microtubular channels (c_k) in such a way that the analyte elements (a_i)

i) enter competitively bond with the analogue elements (b_m),

ii) take the place of some of the analogue elements (b_m) and their conjugated indicator elements (u_m),

iii) and are immobilised on the internal surfaces (sep_k) of the channels (c_k) of the reaction chamber (Cre),

d) a lateral integral measurement transducer system (T) for the extensive state variable (E) is positioned

i) entirely outside the enclosing surface (Sev) of the reaction chamber (Cre),

ii) and strictly facing the impermeable lateral face (slat),

e) finally, by means of the lateral integral measurement transducer system (T) an integral measurement $\Delta E = \Sigma_{k=1...n} \Sigma_{ijm} (dE)_{ijkm}$ is carried out (that is to say a summation) of the variations of the said extensive state variable (E), each elementary signal $(dE)_{ijkm}$ expressing the disappearance of the complexes (analogue element (b_m) = indicator element (u_m)) simultaneously for all the elementary volumes (ve_{ck}) at once, and for all the elementary signals $(dE)_{ijkm}$ in each elementary tube (c_k) at once through the impermeable lateral face (slat).

14) Method according to any one of the preceding Claims 1 to 13 for the production of a solid phase biosensor (Sen), the said method previously consisting of:

a) bringing together and disposing substantially parallel a plurality of tubes (C_1, C_2, ..., C_k, ..., C_n) which are initially distant and are made from a fusible material (such as glass),

b) feeding through a treatment furnace (61) the bundle (62) comprising the plurality of tubes (C_1, C_2, ..., C_k, ..., C_n) in such a way as to soften it at a linear feeding speed (Va),

c) downstream of the furnace (62) drawing the bundle (62) comprising the plurality of tubes (C_1, C_2, ..., C_k, ..., C_n) at a drawing speed (Ve) higher than the feeding speed (Va),

d) thus forming by contact and softening a bundle in the form of a continuous monolithic array (65) of microtubular channels (c_1, c_2, ..., c_k, ..., c_n),

e) periodically dividing this bundle in the form of a continuous array (65) by means of a cutting means (66) in order to form a plurality of monolithic reaction chambers (Cre) in the form of a multi-microtubular array (18),

f) chemically treating each monolithic reaction chamber (Cre) in the form of a multi-microtubular array in such a way as to deposit and fix in a homogeneous manner on the internal surface (sep_k) of each microtube (c_k) a plurality of receptor elements (r_j) of a receptor component (R) or a plurality of analogue elements (b_m) of an analogue component (B) [such as an antibody, a nucleic acid, ...].

15) Sensor (Sen) for evaluation of the concentration of analyte elements (a_i) of an analyte (A) which are present in a fluid sample (F) initially included in a sample volume (Vec), this sensor being of the type constituted by:

a) a reaction chamber (Cre) which provides internally a test volume (Vep)

i) in the interior of which a fraction of the fluid sample (F) is channelled,

ii) circumscribed by an enclosing reaction surface (Sev) constituted by:

- a permeable upstream front face (sfam),
- a permeable downstream front face (sfav) opposite permeable upstream front face (sfam),
- and a substantially cylindrical impermeable lateral face (slat) connected by its two ends to the peripheries of the said two upstream (sfam) and downstream (sfav) faces;

b) at least one active component (chemical and/or biological) known as a receptor (R) which is placed in contact with the fluid sample (F) within the test volume (Vep),

i) of which the receptor elements (r_j) have an affinity with the analyte elements (a_i) in order to detect them,

ii) and also having the property [alone or in combination with another active component known as a indicator (U) likewise introduced into the interior of the test volume (Vep)] of modifying a measurable extensive state variable (physical and/or chemical) (E) by an elementary signal (dE) at each occurrence [or according to a

certain law of probability] at the time of an event of recognition of an analyte element (a_i) by a receptor element (r_j),

c) a transducer system (T) for measurement of the extensive state variable (E) in order to quantify the presence of the analyte elements (a_i) in the fluid sample (F) ;

this sensor (Sen) being characterised in that in combination:

d) on the one hand, its reaction chamber (Cre) is a multi-microtubular array (18) constituted by the joining of a plurality of cylindrical microtubular channels (c_1, c_2, ..., c_k, ..., c_n) of substantially equal lengths (l) which are disposed substantially parallel and multi-tangent in such a way as to delimit a dense plurality of adjacent separate convex elementary volumes (vec_1, vec_2, ..., vec_k,..., vec_n) which are open their two ends (ee_k, es_k) and of which the joining forms the non-convex global test volume (Vep), the said non-convex global test volume (Vep) being circumscribed by the enclosing reaction surface (Sev) of which the permeable upstream (sfam) and downstream (sfav) front faces are situated at right angles to the inlet (se_k) and outlet (ss_k) sections of the micro-tubular channels (c_k) ;

e) on the other hand, its transducer system (T) for lateral integral measurement of the extensive state variable (E),

i) is situated entirely

- outside the enclosing surface (Sev) of the reaction chamber (Cre),
- and strictly facing the impermeable lateral face (slat),

ii) and delivers an integral measurement $\Delta E = \Sigma_{k=1...n} \Sigma_{ij} (dE)_{ijk}$, (that is to say a summation) of the variations of the said extensive state variable (E) simultaneously for all the elementary volumes (vec_k) at once, and for all the elementary signals $(dE)_{ijk}$ in each microtubular (c_k) at once through the impermeable lateral face (slat),

in such a way as to quantify globally the presence of the analyte elements (a_i) in the fluid sample (F) in all the microtubular channels (c_k) at once.

16) Immunomagnetic sensor (Sen) according to Claim 15 of the type in which:

a) a fraction at least of the receptor elements (r_j) is combined with indicator elements (u_j) of another active component known as a indicator (U) in such a way as to modify a measurable extensive state variable (physical and/or chemical) (E) by an elementary signal (dE) at each occurrence [or according to a certain law of probability], at the time of an event of recognition of an analyte element (a_i) by a receptor element (r_j),

b) a transducer system (T) for measurement of the extensive state variable (E) in order to quantify the presence of the analyte elements (a_i) in the fluid sample (F), comprising
   i) an emitter (11) of a magnetic field (H),
   ii) and a receiver (13) of a magnetic field (H) connected to a secondary current analysis device (12),

this sensor (Sen) being characterised in that in combination:

c) on the one hand, the indicator elements (u_j) are constituted by super-paramagnetic particles [and in particular super-paramagnetic micro-granules (sp_j)],

d) on the other hand, the said emitter (11) and receiver (13) of a magnetic field (H) are situated
   i) entirely outside the enclosing surface (Sev) of the reaction chamber (Cre) in the form of a multi-microtubular array,
   ii) and strictly facing the impermeable lateral face (slat).

17) Immunomagnetic sensor (Sen) according to Claim 16, characterised in that

a) its magnetic field emitter (11) is formed by a primary winding (71) of coils (74) connected to a primary current source (72),

b) its magnetic field receiver (13) is formed by a secondary winding (73) of coils (74) connected to a secondary current analysis device (12),

c) the primary (71) and secondary (73) windings of coils (74) surround the impermeable lateral face (slat) of the reaction chamber (Cre) in the form of a multi-microtubular array.

18) Sensor (Sen) according to Claim 15, characterised in that its reaction chamber (Cre) in the form of a cylindrical monolithic multi-microtubular array (18) is covered with a protective casing (19) in such a way as to form a mobile test cartridge (Car).

19) Sensor (Sen) according to Claim 18, characterised in that the protective casing (19) of its reaction chamber (Cre) is cylindrical.

20) Sensor (Sen) according to Claim 18, characterised in that the protective casing (19) of its reaction chamber (Cre) is conical.

21) Sensor (Sen) according to Claim 18, characterised in that the protective casing (19) of its reaction chamber (Cre) is moulded on over the reaction chamber (Cre).

22) Sensor (Sen) according to Claim 18, characterised in that the protective casing (19) of its reaction chamber (Cre) provides internally a reservoir (21) downstream of the reaction chamber (Cre).

23) Sensor (Sen) according to Claim 18, characterised in that the protective casing (19) of its reaction chamber (Cre) is equipped with a lateral sealing element.

24) Sensor (Sen) according to Claim 23, characterised in that the protective casing (19) of its reaction chamber (Cre) is equipped with a lateral sealing element formed by an annular sealing tongue (20) moulded on at right angles to the upstream end face (22) or the downstream end face (26) of the test cartridge (Car).

25) Sensor (Sen) according to Claim 18, characterised in that the protective casing (19) of its reaction chamber (Cre) is provided with an air hole (25) produced on the downstream end face (26) of the cartridge (Cre).

26) Sensor (Sen) according to Claim 15, characterised in that a sampling needle (39) is adapted in a sealed and removable manner on the protective casing (19) of the reaction chamber (Cre) facing the upstream face (22) of the cartridge (Cre) situated on the side of the permeable upstream front face (sfam) of the reaction chamber (Cre).

27) Sensor (Sen) according to Claim 18, characterised in that the protective casing (19) of the reaction chamber (Cre) is extended:

a) upstream of the upstream end face (22), situated on the side of the permeable upstream front face (sfam) of the multi-microtubular reaction chamber (Cre),

b) in the form of a sampling cone (80) provided with a sampling recess (81) in its end (82).

28) Sensor (Sen) according to Claim 18, characterised in that the protective casing (19) of its multi-microtubular reaction chamber (Cre) is covered laterally with an identification label (83).

29) Sensor (Sen) according to Claim 15 for evaluation of the concentration of a group of analytes (A_1, A_2, A_3, ..., A_p, ...) which are present in a fluid sample (F) initially included in a sample volume (Vec), this sensor being of the type formed by:

a) a multi-stage reactor tube (90), in the interior of which a fraction of the fluid sample (F) is channelled,

b) a plurality of reaction chambers (Cre_1, Cre_2, Cre_3, ..., Cre_p, ...) of substantially equal cross-sections ($SCre_p$), disposed coaxially in a chain and sealed laterally within the reactor tube (90),

c) at least a plurality of active components known as receptors (R_1, R_2, R_3, ..., R_p, ...) which are placed in contact with the fluid sample (F) within the test volumes (Vep_p),

i) of which the receptor elements (r_{pj}) have an affinity with the analyte elements (a_{pi}) of at least one analyte (A_p) in order to detect them,

ii) and also having the property [alone or in combination with another active component known as an indicator (U) likewise introduced into the interior of the test volume (Vep)] of modifying a measurable extensive state variable (physical and/or chemical) (E) by an elementary signal (dE) at each occurrence [or according to a certain law of probability] at the time of an event of recognition of an analyte element (a_{pi}) by a receptor element (r_{pj}),

d) a plurality of transducer systems (T_1, T_2, T_3, ..., T_p, ...) for lateral integral measurement of the extensive state variable (E), each comprising

i) at least one physical measurement receiver (Rmp_1, Rmp_2, Rmp_3, ..., Rmp_p, ...) [such as in particular a magnetic field receiver (13)],

ii) each physical measurement receiver (Rmp_p) fitting over the multi-stage reactor tube (90) at right angles to a corresponding reaction chamber (Cre_p),

e) a system for supplying a plurality of receptor reagents (R_1, R_2, R_3, ..., R_p, ...) specific to the analytes (A_1, A_2, A_3, ..., A_p, ...) ;

this multi-analyte sensor (Sen) being characterised in that in combination:

f) on the one hand, at least two of the reaction chambers (Cre_p) are formed by a multi-microtubular array (18) formed by the joining of a plurality of cylindrical microtubular channels (c_{p1}, c_{p2}, ..., c_{pk}, ..., c_{pn}),

g) on the other hand, at least two transducer systems (T_1, T_2, T_3, ..., T_p, ...) for lateral integral measurement of the extensive state variable (E),

i) are situated entirely

- outside the enclosing reaction surface (Sev_p) of the corresponding reaction chamber (Cre_p),
- and strictly facing the corresponding impermeable lateral face ($slat_p$),

ii) and carry out an integral measurement $\Delta E_p = \Sigma_{k=1...n} \Sigma_{ij} (dE)_{ijpk}$, (that is to say a summation) of the variations of the said extensive state variable (E) simultaneously for all the elementary volumes (vec_{pk}) at once, and for all the elementary signals $(dE)_{ijpk}$ in each elementary channel (c_{pk}) at once through the corresponding impermeable lateral face ($slat_p$) of the reaction chamber (Cre_p).

30) Sensor (Sen) according to Claim 15, further provided with a mobile device (100) for sampling by mobile test cartridge (Car) of analyte elements (a_i) of an analyte (A) [that is to say soluble chemical entities or live or dead micro-organisms, or parts of micro-organisms] which are present in a fluid sample (F), comprising the combination between:

a) a sampling block (102) having an internal sampling cavity (103) of a revolutionary shape (cylinder or truncated cone),
b) a mobile cartridge (Car)
   i) of a revolutionary shape (cylinder or truncated cone) complementary to that of the internal sampling cavity (103),
   ii) including internally a reaction chamber (Cre) in the form of a monolithic multi-microtubular array (18),
   iii) introduced in a mobile manner into the internal sampling cavity (103) of the sampling block (102),
   iv) and sealed laterally relative to the wall (104) of the internal sampling cavity (103),
c) a means for retaining (105) the mobile cartridge (Car) in the sampling block (102),
d) a means for sealing (106) the sampling block (102) after introduction of the mobile cartridge (Car) into the interior,
   i) the said sealing means (106) being possibly merged with the said retaining means (105),
   ii) providing after activation at least two openings (111, 112) in the sampling block (102):
      - an upstream opening (111) for taking the fluid sample (F),
      - and a downstream opening (112)
e) a pump (115) for movement of the reagents and fluid sample (F), connected to one or the other of the upstream (111) or downstream (112) sampling openings.

31) Sensor (Sen) according to Claim 15, further provided with a mobile device for sampling and indication (121) by mobile test cartridge (Car), according to Claim 30, characterised in that it further comprises at least one reservoir (122) for chemical and/or biological reagent (and in particular for receptor (R)) connected to one or the other of the:
a) upstream sampling opening (111),
b) and/or downstream sampling opening (112),
of the sampling block (102),
c) and of which the pump (115) for movement of the fluids is situated between the opening (111 or 112) and the reservoir (122) for reagents.

32) Sensor (Sen) according to Claim 15, further provided with an independent device for indication after sampling (131) by mobile test cartridge (Car) of analyte elements (a_i) of an analyte (A) which are present in a fluid sample (F), comprising the combination between :
a) an indication block having an internal indication cavity of revolutionary shape (cylinder or truncated cone),

b) a mobile cartridge (Car)
   i) of a revolutionary shape (cylinder or truncated cone) complementary to that of the internal indication cavity,
   ii) including internally a reaction chamber (Cre) in the form of a multi-microtubular array,
   iii) introduced in a mobile manner into the internal indication cavity of the indication block,
   iv) and sealed laterally relative to the wall of the internal indication cavity,
c) a means for retaining the mobile cartridge (Car) in the indication block,
d) a means for sealing the indication block after introduction of the mobile cartridge (Car) into the interior of the internal indication cavity,
   i) the said sealing means possibly being merged with the said retaining means,
   ii) providing after activation at least two openings in the indication block :
      - an upstream opening for introduction of reagents,
      - and a downstream opening,
e) a pump for movement of the reagents and fluid sample, connected to one or the other of the upstream opening for introduction of reagent or the downstream opening.

33) Sensor (Sen) according to Claim 15, further provided with an independent device for measurement after sampling (151) by mobile test cartridge (Car) of analyte elements (a_i) of an analyte (A) which are present in a fluid sample (F), comprising the combination between :
a) a transduction block (Cme) providing an internal measurement cavity (Eme) of a revolutionary shape (cylinder or truncated cone),
b) a mobile cartridge (Car)
   i) of revolutionary shape (cylinder or truncated cone) complementary to that of the internal measurement cavity (Eme),
   ii) including internally a reaction chamber (Cre) in the form of a multi-microtubular array (18),
   iii) introduced in a mobile manner into the internal measurement cavity (Eme) of the transduction block (Cme),
   iv) and sealed laterally relative to the wall (154) of the internal measurement cavity (Eme),
c) a means for retaining (155) the mobile cartridge (Car) in the transduction block (Cme),
d) a transducer system (T) for lateral integral measurement of the extensive state variable (E), comprising at least one physical

measurement receiver [such as in particular a magnetic field receiver (13)], connected to the transduction block (Cme) and situated entirely

i) outside the internal measurement cavity (Eme),

ii) and strictly facing the internal measurement cavity (Eme).

34) Sensor (Sen) according to Claim 15, further provided with an independent device for indication and measurement (160) after sampling by mobile test cartridge (Car) of analyte elements (a_i) of an analyte (A) which are present in a fluid sample (F), according to Claim 33, further comprising in combination:

a) a means for sealing (156) the block after introduction of the mobile cartridge (Car) into the interior,

i) the said sealing means (156) being possibly merged with the said retaining means (155),

ii) providing after activation at least two openings in the sampling block:

- an upstream feeding opening (161),
- and a downstream opening (162),

b) a pump (165) for movement of the sample fluids and/or reagents, connected to one or the other of the upstream (161) or downstream (162) sampling openings.

35) Sensor (Sen) according to Claim 15, further provided with a sequential robot device (171) for analysis by mobile test cartridges (Car), formed in combination by:

a) a rigid cartridge support (172) comprising a plurality of blocks (173_a, 173_b, 173_c, 173_d, ...) spaced from one another at a constant pitch (p),

b) a means for periodic displacement of the cartridge support (172) by a spacing (p') equal to the said constant pitch (p) such that the plurality of blocks (173_a, 173_b, 173_c, 173_d, ...) is periodically simultaneously displaced facing an identical plurality of stopping points (181_a, 181_b, 181_c, ...),

c) a plurality of mobile test cartridges (Car_a, Car_b, Car_c, Car_d, ...)

i) including internally a reaction chamber (Cre_a, Cre_b, Cre_c, Cre_d, ...) in the form of a multi-microtubular array (18),

ii) and inserted into the interior of the multitude of blocks (173_a, 173_b, 173_c, 173_d, ...),

d) at least one device for injection of liquid (201_a, 201_b, 201_c, ...) (sample and/or reagent) situated facing a stopping point (181_a, 181_b, 181_c, ...).

36) Sensor (Sen) according to Claim 15, further provided with a sequential robot device (171) for analysis by mobile test cartridges (Car_a, Car_b, Car_c, Car_d, ...) with a reaction chamber (Cre_a, Cre_b, Cre_c, Cre_d, ...) in the

form of a multi-microtubular array (18), according to Claim 35, this device (171) being characterised in that furthermore:

a) its rigid cartridge support (172) is formed by a carousel (182),

b) the plurality of blocks (173_a, 173_b, 173_c, 173_d, ...) is positioned on the periphery of the carousel (182) and they are separated by an equal angle at the top (α),

c) the means for periodic displacement ensures the periodic rotation of the carousel (182) at an angle (α).

37) Sensor (Sen) according to Claim 15, further provided with a sequential robot device (171) for analysis by mobile test cartridges (Car_a, Car_b, Car_c, Car_d, ...) with a reaction chamber (Cre_a, Cre_b, Cre_c, Cre_d , ...) in the form of a multi-microtubular array (18), according to Claim 35, this device (171) being characterised in that it further includes a transducer system (T) for lateral integral measurement of the extensive state variable (E), comprising at least one physical measurement receiver (such as in particular a magnetic field receiver (13)),

a) positioned at a stopping point (181_a, 181_b, 181_c, ...),

b) periodically mobile perpendicular to the movement of the cartridge support (172),

c) and periodically coming to mount the test cartridge (Car_d) situated facing it at the stopping point (181_a, 181_b, 181_c, ...), closely surrounding the external surface of the test cartridge (Car_d).

38) Test cartridge (Car_1) for carrying out the method according to any one of the preceding Claims 1 to 13, comprising the characteristic combination between:

a) at least one reaction chamber (Cre_1) in the form of a multi-microtubular array (18),

b) and the protective casing (19) covering the said reaction chamber (Cre_1).

39) Multi-chamber test cartridge (Carm) according to Claim 38, characterised in that it further comprises:

a) at least two reaction chambers (Cre_1, ..., Cre_3, ...) in the form of a multi-microtubular array, of identical cross-section, positioned along the axis (zz'),

b) and a protective casing (19) simultaneously covering the reaction chambers (Cre_1, ..., Cre_3,...).

40) Multi-chamber multi-test cartridge (MCarm) according to Claim 38, characterised in that furthermore it is formed by a plurality of test cartridges (Car_1, Car_2, Car_3, ...) disposed end to end in series along one and the same axis (zz').

41) Multi-chamber multi-test cartridge (MCarm) according to Claim 40, characterised in that at least two of its test cartridges (Car_1, Car_2, Car_3, ...) are fitted into one another.